

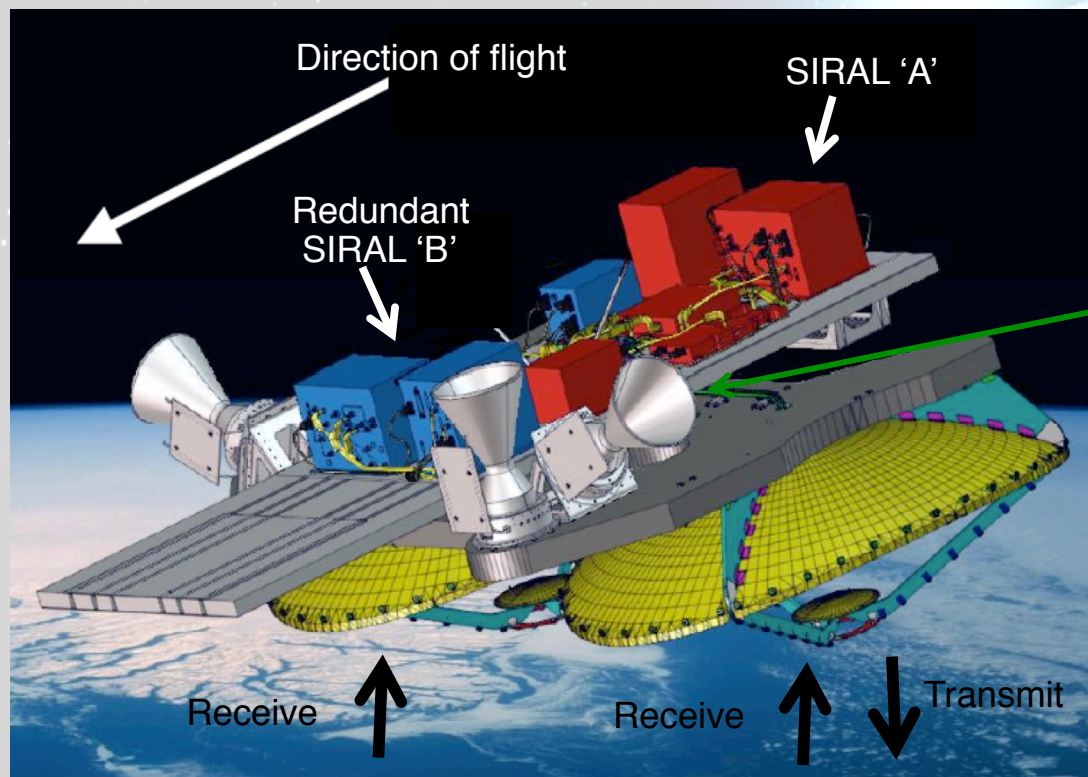


Estimating Pitch Angle of CryoSat-2, Using the Power Distribution of the Synthetic Aperture

***Natalia Galin, NOAA, Laboratory for Satellite Altimetry, United States
Duncan Wingham, NERC, United Kingdom***



The CryoSat-2 payload and operating modes



- “SARIN mode”

$$\theta_{STR} \cong \hat{m}_b[x]$$

$$\mu_{STR} \cong -\hat{n}_n[y]$$

$$\lambda_{STR} \cong \hat{m}_b[y]$$

forms
ter.
eline

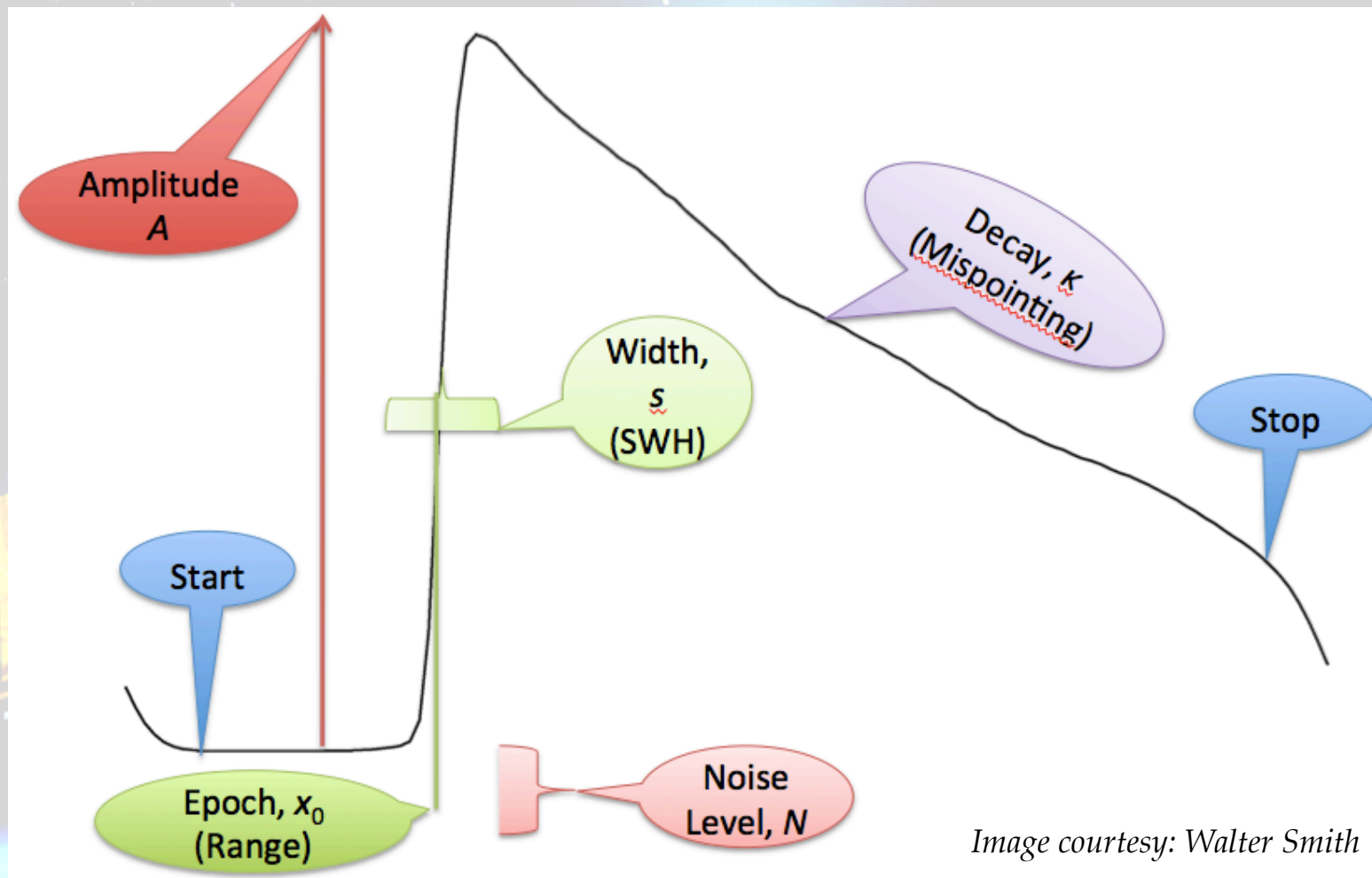
- “SAR mode” (SAR)

Illuminated area narrowed
along-track by synthetic
aperture processing

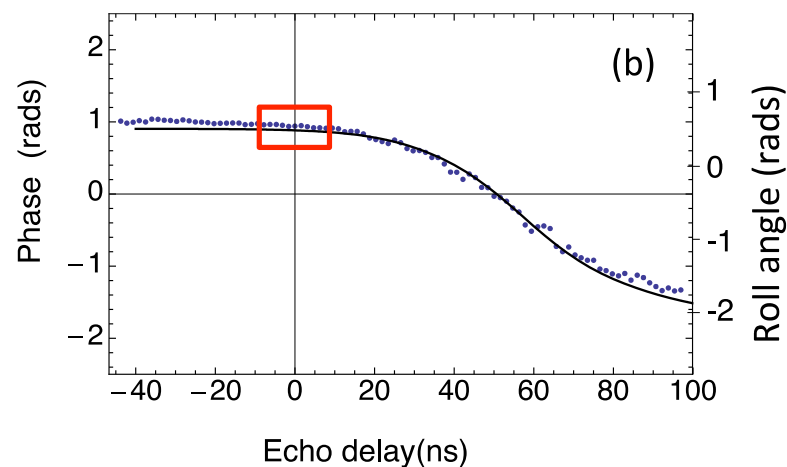
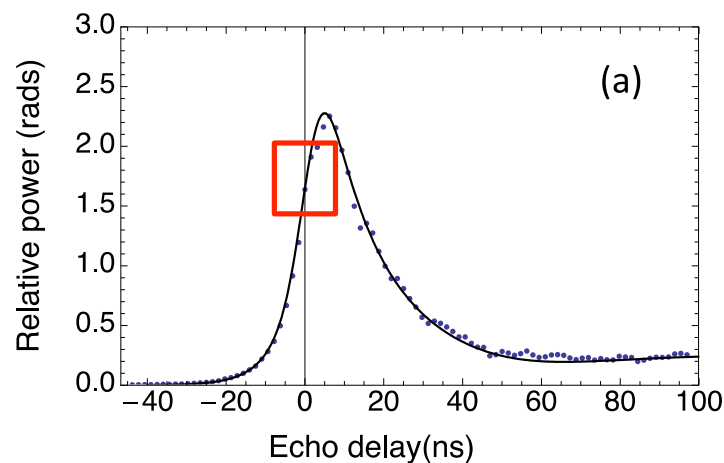
- “Low resolution mode” (LRM)

Conventional pulse-limited
altimeter but with a slightly
elliptical antenna

Motivation – estimating satellite mispointing angles

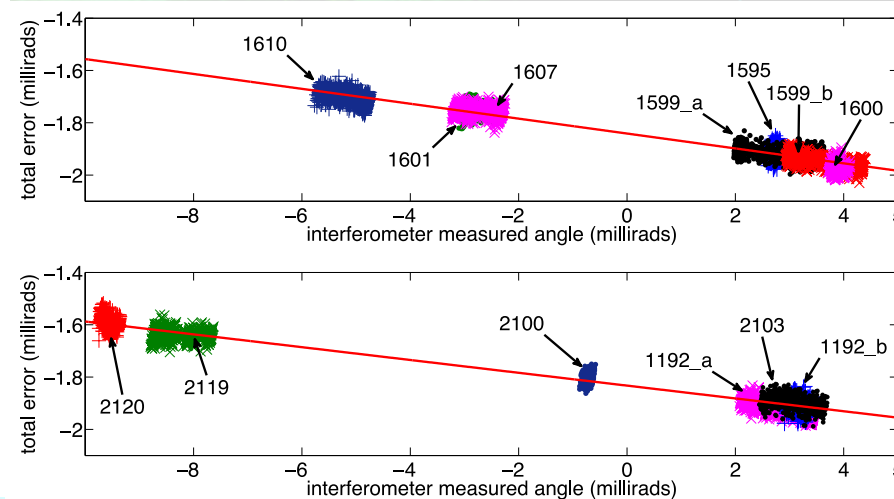


Estimating the interferometer angle

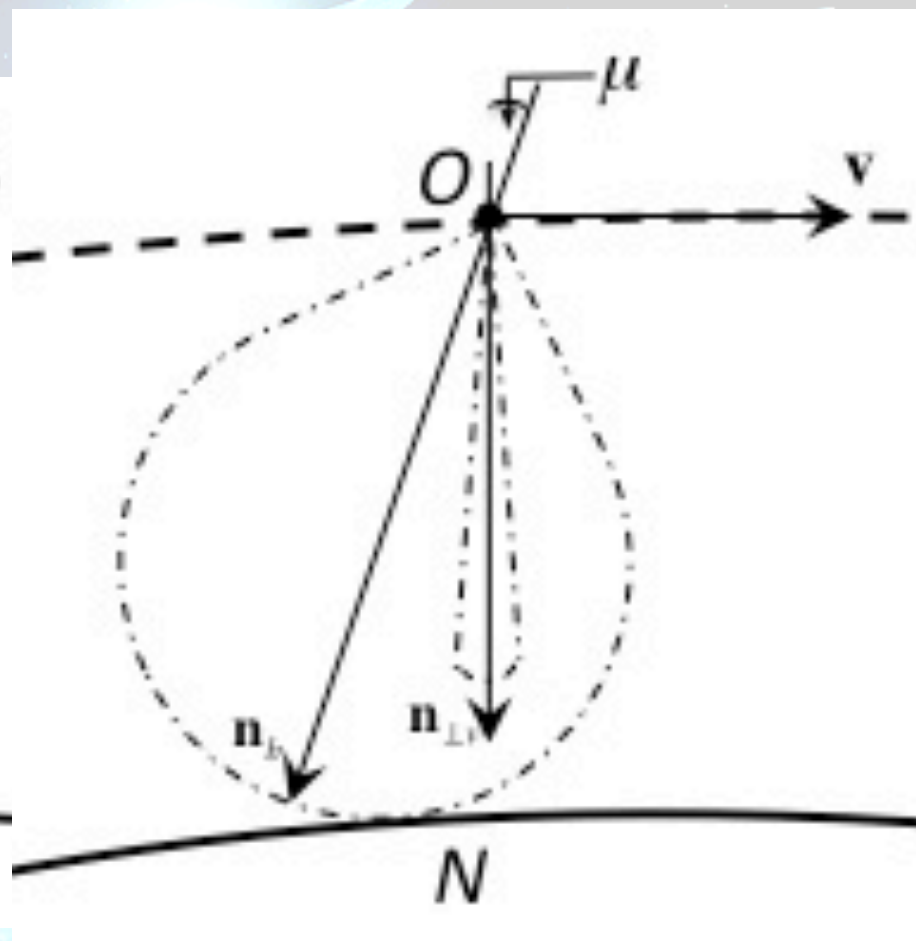
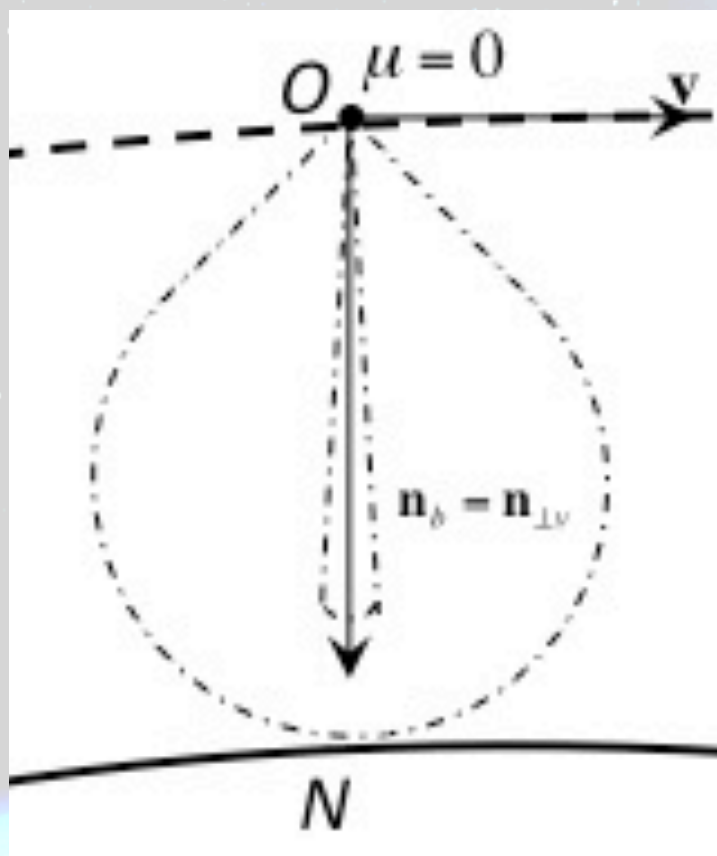


$$\sin(\theta) = \text{Arg}(\Psi(0)) / k_0 B + \varphi_d$$

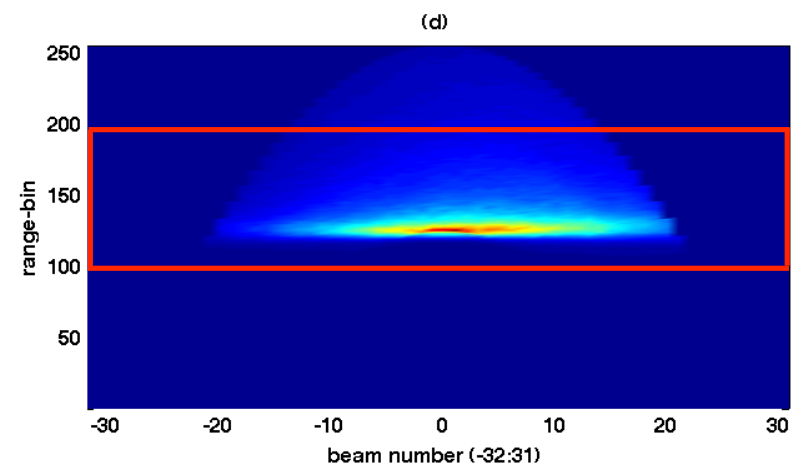
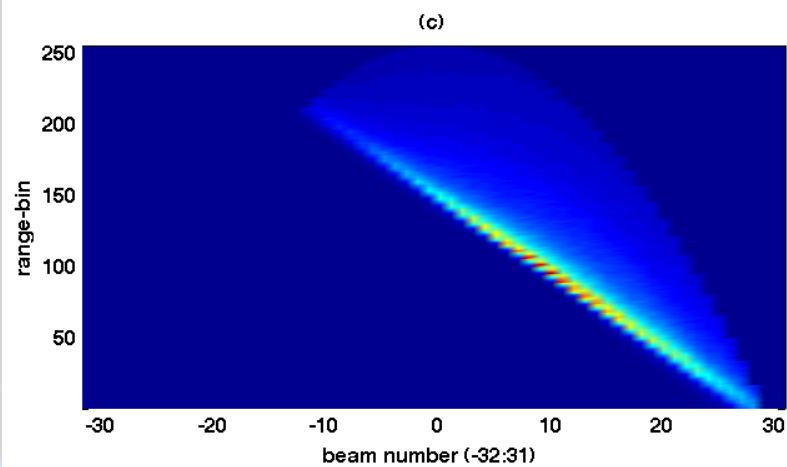
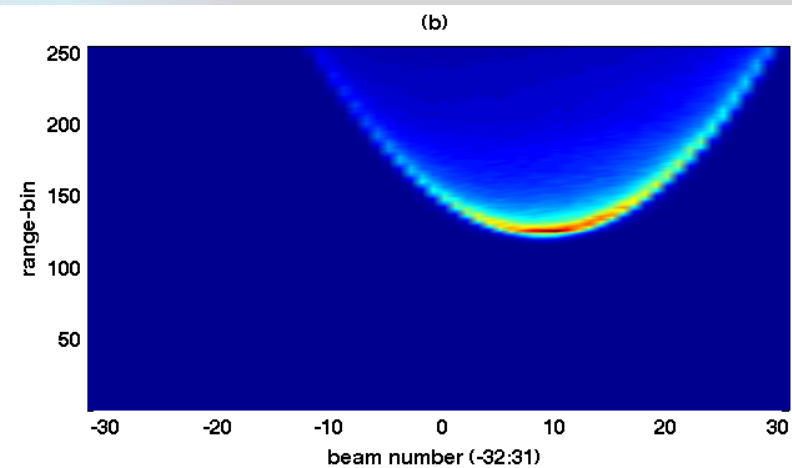
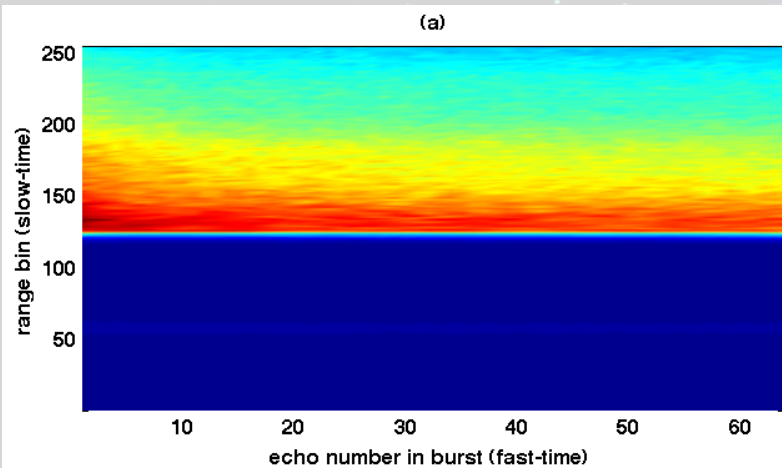
Measured star tracker offset:
0.612 radians of phase difference.



Principle of measurement

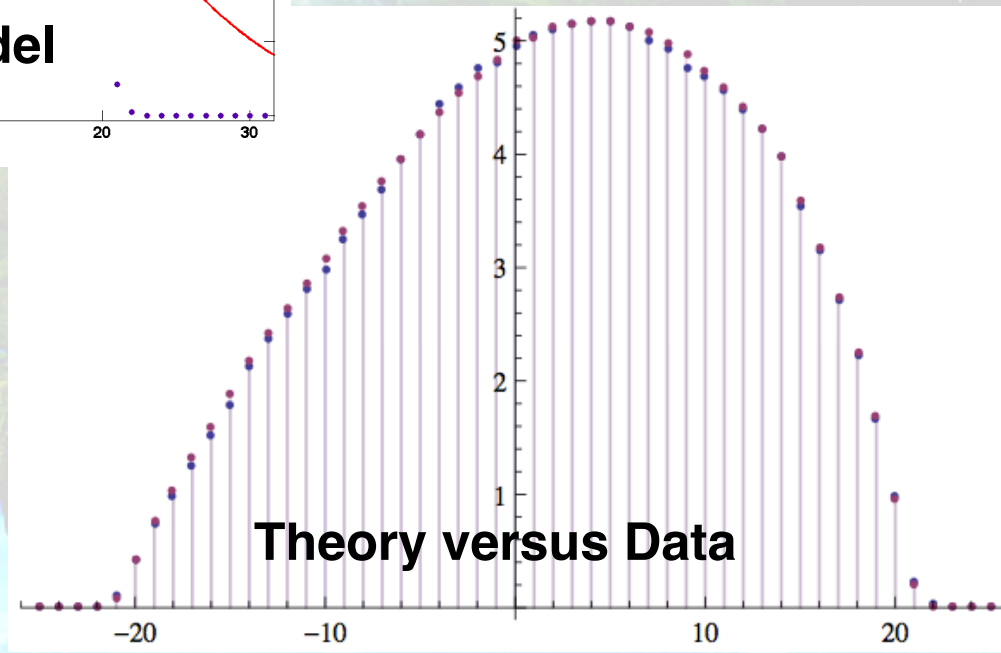
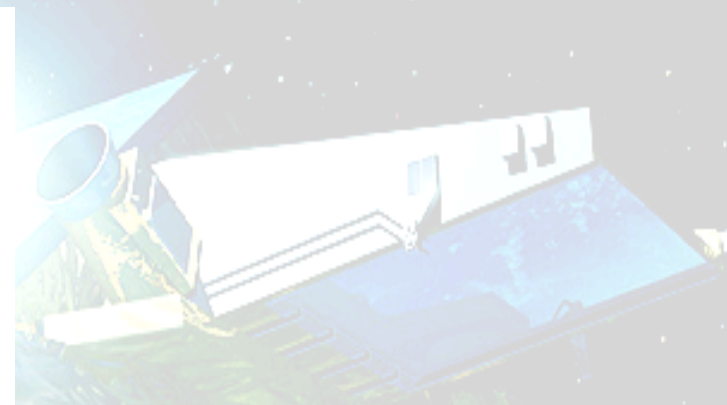
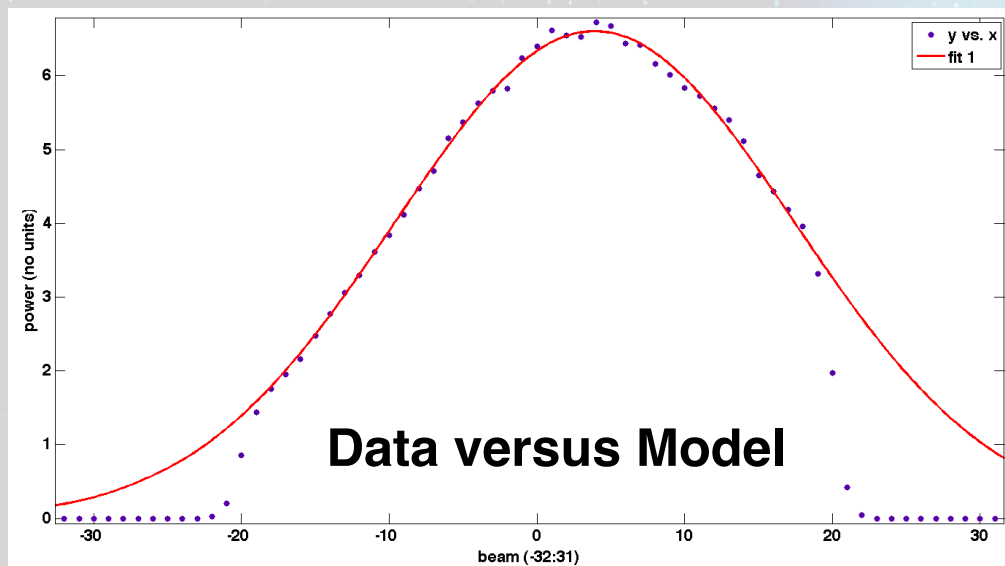


Processing steps





Retrieving the pitch angle...



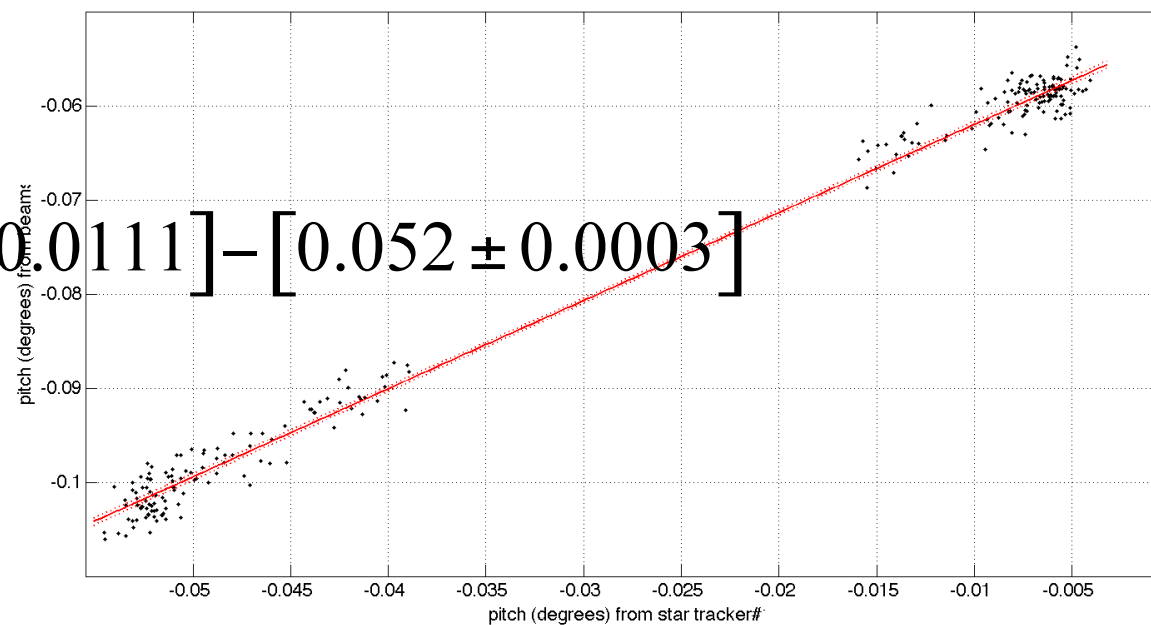


Cont... retrieving the pitch angle



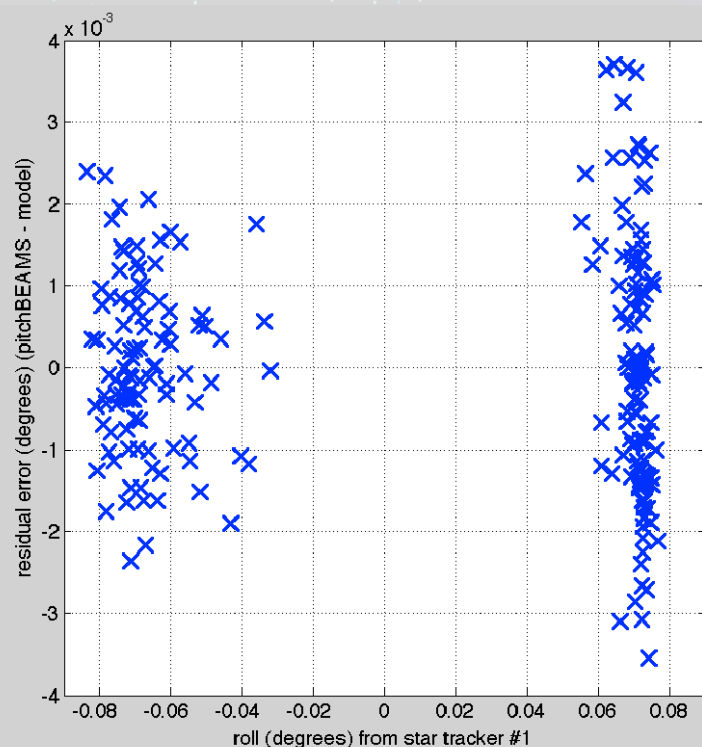
$$\mu_{FBR} = 0.97\mu_{STR}$$

$$\mu_{FBR} = [0.94\mu_{STR} \pm 0.0111] - [0.052 \pm 0.0003]$$





Performance and residual errors



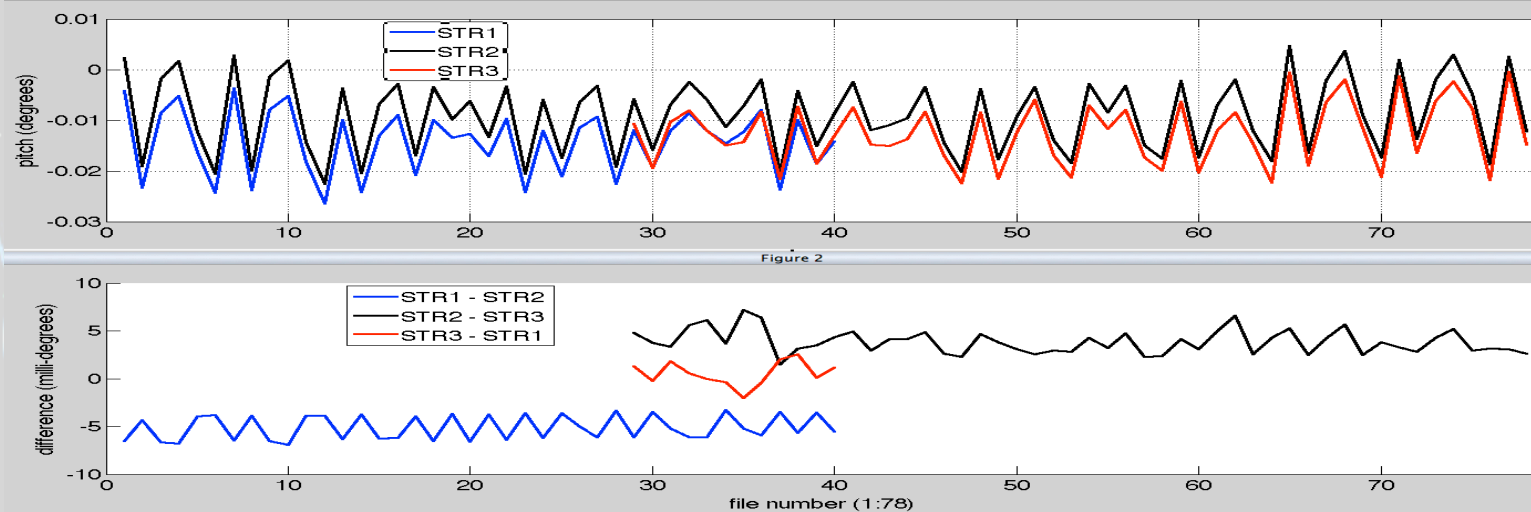
For all 26 files, the residual errors are independent, and not a function of any additional geophysical parameter, e.g. roll.

FILE NUMBER				
<u>ascending</u>	σ_r	$\sigma_r / \sqrt{(N_a - 1)}$	$\bar{\epsilon}_r$	$2\sigma_r / \sqrt{(N_a - 1)}$
1	22.69	7.56	18.62	15.13
2	28.98	9.66	-31.82	19.32
4	39.08	13.03	17.09	26.05
6	49.74	18.80	4.99	37.60
15	39.22	13.07	3.92	26.15
18	59.05	19.68	-7.54	39.37
26	44.68	14.89	21.16	29.78
28	26.60	8.87	2.61	17.74
37	27.02	9.01	16.45	18.01
38	26.41	8.80	-9.40	17.60
40	48.27	18.24	-6.29	36.49
47	20.71	6.90	11.15	13.81
48	50.61	16.87	-11.14	33.74
<u>descending</u>				
3	36.01	12.00	-2.65	24.01
9	88.91	29.64	12.29	59.27
10	30.22	10.07	-12.19	20.15
12	33.05	11.02	4.23	22.03
21	28.97	9.66	0.71	19.31
22	27.71	9.24	-20.21	18.47
31	32.04	10.68	10.96	21.36
32	16.14	5.38	-5.86	10.76
43	15.86	5.29	14.59	10.57
44	21.40	7.13	-15.66	14.27
51	18.46	6.15	29.11	12.30
52	38.71	12.90	-16.61	25.81
54	28.62	9.54	14.36	19.08



Summary

- We estimate the star-tracker offsets of CryoSat-2 as: *Other studies:*
 - roll bias: from SARIN calibration, 0.1062 degrees, *Roll bias: 0.0848*
 - pitch bias: from SAR calibration, 0.052 degrees. *Pitch bias: 0.0962*
- Our results are based on data from star tracker #1 only. However, comparison of the pitch reported by the three star trackers shows very close agreement, hence, we believe that the offset is the same.



- Finally, we used our analysis to verify the along-track half-power beamwidth of the antenna. We estimate this value from the half-power width of the fitted Gaussian as: **1.0912 ± 0.0077** degrees.



MATLAB code for SAR processing CryoSat-2 FBR data:

https://github.com/ngalin/cryosat2_fbr2sar

